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ENERGY AND SUSTAINABLE DEVELOPMENT: NEW AND RENEWABLE SOURCES OF ENERGY

Update on new and renewable sources of energy

Report of the Secretary-General

SUMMARY

The General Assembly, in resolution 46/235, decided to establish the Committee on New and Renewable Sources of Energy and on Energy for Development. The Committee will retain the mandate of the former Committee on the Development and Utilization of New and Renewable Sources of Energy. The General Assembly, in resolution 45/208, emphasized the need for the development of new and renewable sources of energy in accordance with the fundamental objectives of the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy. The Assembly reaffirmed the importance and validity of the principles and objectives of the Programme and the urgent need to promote a higher degree of independence and environmentally sustainable new and renewable sources of energy for all countries.

The General Assembly, in resolution 47/190, endorsed the Rio Declaration on Environment and Development, Agenda 21 and the Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests,

* E/C.13/1993/1.

and urged Governments and organs, organizations and programmes of the United Nations system as well as other intergovernmental and non-governmental organizations to take the necessary action to give effective follow-up to those instruments. The General Assembly also called upon all concerned to implement all commitments, agreements and recommendations reached at the United Nations Conference on Environment and Development (UNCED), especially by ensuring provision of the means of implementation under section IV of Agenda 21.

In that context, the present report examines developments in the field of new and renewable sources of energy, mainly those that have arisen since the meeting of the United Nations Intergovernmental Expert Group on New and Renewable Sources of Energy in August 1991. During the middle to the late 1980s, a decline in the price of oil caused Governments and the private sector to cut back investments in new and renewable sources of energy and interest in its development and utilization waned. Recently, however, concern over the state of the environment, particularly the fear of adverse climate change, has rekindled interest in new and renewable sources of energy and has given new impetus to its development.

The present report reviews current technology in the field and examines the extent of its utilization. The share of renewable energy in total energy consumption in 1990 was 17.7 per cent. If only solar, wind and geothermal energy, and modern biomass utilization are included, that share dwindles to a mere 1.6 per cent. New and renewable energy technologies have reached varying degrees of maturity. Traditional biomass utilization, in the form of fuelwood and charcoal burning, has caused numerous problems, including environmental damage and localized shortages of supply. In industrialized countries, the development of larger-scale, mostly grid-connected systems has made some progress. In developing countries, successful government efforts and private initiatives have shown that renewable energy is a viable and in some cases completely user-financed alternative for rural areas without access to electricity.

At the international level, energy issues are explicitly or implicitly covered in the Rio Declaration on Environment and Development and Agenda 21. The report provides examples of regional and national policies, plans and targets that have been formulated mainly in the wake of UNCED.

The growth of apprehension over environmental degradation has resulted in renewable energy figuring prominently in some projections for low-carbon energy scenarios in the future. However, projections are often based on assumptions that have not yet been tested in the market-place, such as environmental and internalized costs. They are also often based on assumptions of massive government-supported research and development programmes, whereas current trends indicate a movement away from large-scale government involvement. Estimates of the share of new and renewable sources of energy in world energy consumption made by the United Nations Solar Energy Group on Environment and Development range from 33 to 50 per cent by 2020.

Estimates made by the World Energy Council, on the other hand, suggest a 21.3 per cent share by 2020 under a current policies scenario and a 29.6 per cent share under an ecologically driven scenario.

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INTRODUCTION

1. The main objective of the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy, 1/ which was adopted at the United Nations Conference on New and Renewable Sources of Energy held in Kenya from 10 to 21 August 1981 and endorsed by the General Assembly in its resolution 36/193 of 18 February 1982, was to promote reliance on a wider energy mix rather than on exclusive reliance on fossil fuels. It also promoted energy planning and conservation and addressed the critical energy situation of rural areas in developing countries. It saw new and renewable sources of energy as the critical element in solving many of those problems. Five broad policy areas for concerted action were identified in the Nairobi Programme of Action, to be implemented according to national plans and priorities with the support of the international community. Those areas were: energy assessment and planning; research, development and demonstration; transfer, adaptation and application of mature technologies; information flows; and education and training. Meeting rural energy requirements within the context of integrated rural development programmes was deemed to be a matter of great urgency, especially for developing countries.

I. PROGRESS IN THE IMPLEMENTATION OF THE NAIROBI PROGRAMME OF ACTION

2. In reaction to the critical energy situation that prevailed in the 1970s, many Governments in industrialized countries instituted and implemented successful policies for energy efficiency and conservation, which resulted in a decrease in the rate of growth of energy consumption in most of those countries. Successful energy efficiency and conservation programmes, as well as the development of non-Organization of Petroleum Exporting Countries (OPEC) oil supplies and nuclear power, led to an oversupply in the oil market. That in turn led to lower oil prices, which bottomed out at less than US$ 10 per barrel in mid-1986. The need for diversification of energy sources because of the insecurity of supplies and high energy prices became less urgent. Many government programmes and research and development funds for new and renewable energy technologies were stopped or drastically reduced. Nevertheless, some progress has been achieved, particularly in wind and solar technologies.

3. Today, more than 10 years after the adoption of the Nairobi Programme of Action, most of the increases in energy consumption are being met by conventional fuels rather than by new and renewable sources of energy. The current share of renewable energy in total energy consumption is estimated at 17.7 per cent. If large-scale hydropower and traditional biomass (fuelwood, dung and charcoal) are excluded, the share becomes very small: only 1.6 per cent of the world total (see table 1).

4. Progress in the implementation of the Nairobi Programme of Action was evaluated by the United Nations Intergovernmental Group of Experts on New and Renewable Sources of Energy, which met in New York from 26 to 30 August 1991 (see A/AC.218/1992/9). The Group of Experts noted that projections indicated that global energy needs would increase by about 75 per cent over the next three

decades and that additional energy needs would be met mainly by existing conventional sources of energy. Developing countries were expected to register higher growth rates in energy demand than other groups of countries. The Group of Experts felt that such a scenario would continue to expose the world economy to great uncertainties involving possible energy instabilities and increasing environmental degradation.

Table 1. Estimates of the contribution of renewable sources of energy in 1990

(Million tons of oil equivalent)

Energy resource	1990
Large hydro	465
Mini-hydro	18
Geothermal	12
Solar	12
Wind	1
Modern biomass	121
Traditional biomass	930
Total renewables	1 559
Total energy	8 808
Renewable share of total energy (percentage)	17.7
Emerging a/ renewable as percentage of total energy	1.6

Source: World Energy Council, Renewable Energy Resources: Opportunities and Constraints 1990-2020.

a/ Emerging = total renewables minus hydro and traditional biomass.

5. Accelerating the development and utilization of environmentally benign new and renewable sources of energy had therefore become an urgent issue. In reviewing progress already made, however, the Group of Experts noted that although there had been an increase in the development and utilization of new and renewable sources of energy in developing countries, on the whole the rate of increase had been slow (see table 2).

Table 2. Renewable energy contribution in developing countries, 1985 and 1990

(Million tons of oil equivalent)

Energy resource	1985	1990
Hydro	133	189
Geothermal	3.5	5
Solar	5	6
Wind	< 1	< 1
Modern biomass	85	72
Traditional biomass	663	842
Total renewables	889.7	1 114

Source: 1985: Report of the Secretary-General entitled "Solar energy: a strategy in support of environment and development" (A/AC.218/1992/5/Rev.1); 1990: H. Khatib, "Solar energy in developing countries", paper presented at the World Solar Summit, Paris, 5-9 July 1993.

6. Progress had been made in large-scale applications of mature technologies, such as hydropower and geothermal energy for electricity generation. Solar energy technologies and wind electric farms had reached maturity. Numerous activities related to the application of small-scale new and renewable sources of energy had taken place; however, their overall impact on the global availability of energy remained insignificant.

7. The production of peat and oil shale had declined but the output of alcohol for energy purposes had nearly tripled, mainly owing to the rapid expansion of the Brazilian programme of gasoline substitution.

8. Traditional sources of energy, including fuelwood, charcoal, draught animal power and agricultural and animal residues, represented the largest share among new and renewable sources of energy. Energy supplies from fuelwood and charcoal were estimated to have provided over 500 million tons of oil equivalent (mtoe) in 1985 and 377 mtoe in 1990. The use of fuelwood, charcoal and agricultural and animal residues for energy in developing countries, however, had resulted in a deterioration of living and environmental conditions.

9. In its recommendations, the Group of Experts emphasized that an adequate energy supply was a basic prerequisite for the continued development of all countries. New and renewable sources of energy had an important role to play in meeting future energy needs in both the rural and urban areas; their development

and utilization should therefore be given the highest priority, especially in the light of increased awareness of the adverse environmental impacts of conventional sources of energy.

10. The main thrust of the Nairobi Programme of Action and its recommendations continued to be valid. However, an overall review of its priorities might be required to reflect the changes that had taken place in such areas as energy, ecology, finance, economic growth and the state of development and application of technologies in the field.

11. Finally, the Group of Experts made a number of recommendations for action at both national and international levels. At the national level, it felt that Governments should, consistent with their national priorities, establish time-bound commitments on the share of new and renewable sources of energy in total national energy consumption and attempt to allocate appropriate national funding to that end.

12. At the international level, the Group recommended that developing countries should be assisted, upon request, in: preparing and implementing training programmes in the various specialized areas of the field, including maintaining educational and training institutions; strengthening or establishing capacities for assembling, manufacturing, testing and controlling the quality of specialized equipment, as well as developing related maintenance and management services; and developing credit and marketing facilities designed to promote the development and use of promising technologies in the field. Centres of excellence in the field should be identified and strengthened and a network of those centres should be set up. Financial assistance should also be strengthened, with bilateral and multilateral institutions, in particular, strengthening their support by pursuing practices conducive to the assessment of energy projects on the basis of full costing of environmental and social impacts.

II. NEW AND RENEWABLE SOURCES OF ENERGY: UPDATE

13. Since the meeting of the Group of Experts in 1991, some new developments have taken place and world-wide estimates on new and renewable sources of energy have been published. During the preparatory process for the United Nations Conference on Environment and Development (UNCED), world awareness grew concerning the potential of new and renewable sources of energy and that awareness has since been enhanced. Similarly, new national energy policies have placed greater emphasis on the subject.

14. This section of the report summarizes progress made in some of the technologies in the field, with emphasis on developments since 1990/91.

A. New and renewable sources of energy technologies

1. Solar energy

15. Both photovoltaic (PV) and solar thermal energy have witnessed increased use since the adoption of the Nairobi Programme of Action. PV cells are now used commercially for communications equipment, consumer goods and as a source of electricity in remote areas. Solar thermal energy, which can be used directly for heating, indirectly for electricity and passively for heating and cooling in buildings, is currently used for industrial process heating, water-heating for domestic use, electricity generation and crop-drying, and is incorporated passively in architectural designs. Recent data on installed capacity of solar energy worldwide for both PV and solar thermal systems are shown in tables 3 and 4, together with net installed electricity capacity.

Table 3. Installed capacity of solar energy in selected developing countries, 1990

Country	Photovoltaic capacity (kilowatts)	Net installed electricity capacity (thousands of kilowatts)	Active heating (terajoules per year)
Burundi	4 124	43	-
China	1 000	98 600	-
Ethiopia	55	393	-
India	4 600	75 995	-
Indonesia	700	11 480	-
Jordan	40	1 048	-
Malaysia	16	5 037	-
Mexico	2 000	29 274	687
Pakistan	266	9 137	-
Philippines	43	6 869	-
Senegal	45	231	-
Sri Lanka	80	1 289	-
Thailand	158	9 722	-
Turkey	-	16 316	377
Uruguay	50	1 681	-
Venezuela	1	18 647	-

Source: Department for Economic and Social Information and Policy Analysis, United Nations Secretariat, based on World Energy Council, 1992 Survey of Energy Resources; and Department for Economic and Social Information and Policy Analysis, United Nations Secretariat, 1991 Energy Statistics Yearbook (United Nations publication, Sales No. E/F.93.XVII.5).

Table 4. Installed capacity of solar energy in selected industrialized countries, 1990

Country or area	Photovoltaic capacity (kilowatts)	Thermal electricity (kilowatts)	Net installed capacity of electricity (thousands of kilowatts)	Active heating (terajoules per year)
Australia	2 000	25	36 782	-
Belgium	15	-	14 140	-
Canada	800	-	104 140	620
Denmark	-	-	9 133	95
Finland	200	-	13 220	30
France	1 000	-	103 410	-
Germany	1 346	-	123 160	212
Israel	80	-	4 135	6 790
Italy	700	-	56 548	520
Japan	1 811	-	194 763	-
Netherlands	400	-	17 441	150
New Zealand	5	-	7 504	-
Norway	1 600	-	27 195	1.5
Republic of Korea	769	-	24 056	76
South Africa	1 200	-	25 890	-
Spain	3 160	-	43 273	1 663
Sweden	10	-	34 189	30
Taiwan Province of China	10	-	..	715
United Kingdom of Great Britain and Northern Ireland	32	-	73 059	357
United States of America	12 000	279 000	775 396	-
Former USSR	100	-	333 100	-

Source: Department for Economic and Social Information and Policy Analysis, United Nations Secretariat, based on World Energy Council, 1992 Survey of Energy Resources; and Department for Economic and Social Information and Policy Analysis of the United Nations, 1991 Energy Statistics Yearbook (United Nations publication, Sales No. E/F.93.XVII.5).

2. Photovoltaic systems

16. Considerable advances have been made in PV cell efficiencies during the 1980s, thanks to research and development efforts, mostly in the United States of America, Japan and Europe. Crystalline silicon cells still have the largest market share, with efficiencies ranging from 11 to 23.1 per cent conversion. However, the much researched thin-film silicon cells have recently had some problems with sales, mainly due to price increases. New developments include the deposition of crystalline silicon in sheet form and further research in other materials, such as cadmium telluride, copper indium diselenide and gallium arsenide. Many of the substances used for cell material are highly toxic and their safe disposal could become a problem with increased use. Even though total PV cell shipments have experienced slower growth recently compared to an average of 15 to 20 per cent until 1991, shipments have almost tripled since 1985 (see table 5). 2/

17. Small domestic PV kits are now being distributed in rural areas in some developing countries; the cost is often met by the user through small credit loans or revolving funds. For example, 100,000 people in Indonesia, formerly without electricity, are now served by a government programme that since 1988 has installed 12,000 small domestic systems totalling 700 kilowatts (Kw) in capacity in remote areas. Monthly cost for the households that have purchased one of those small domestic systems is about US$ 3.75, approximately equivalent to the previous outlay for kerosene, candles and batteries. 3/ A number of other developing countries also have strong if relatively small marketing and dissemination PV programmes, mainly in the form of small kits for television and lighting, in which private-sector initiatives, including local manufacturing and assembly, have met with encouraging results. 4/ In some countries, such as India, the Philippines, Mexico, Sri Lanka, Zimbabwe and Brazil, PV use is increasing, especially for telecommunications and street as well as domestic lighting. Capacities for manufacturing PV cells in developing countries are increasing and it has been estimated that about 100,000 households in developing countries use electricity generated from the sun. 5/

18. Interest has recently arisen in demonstrating the grid-connected application of PV electricity. For example, a plant was recently constructed in Italy near Naples with a capacity of 600 kW, which is expected to reach 3.3 megawatts (MW) by the mid to late 1990s. 6/ Other large-scale plants are located in California, Japan, Germany and Saudi Arabia, with a combined capacity of some 14 megawatts (MW) in 1992. 7/

Table 5. World-wide shipments of photovoltaic modules

(Megawatts)

Country or area	1985	1986	1987	1988	1989	1990	1991	1992
United States of America	7.70	7.10	8.65	11.30	15.50	15.70	16.25	18.40
Japan	10.50	12.60	13.20	12.90	12.70	15.00	18.75	18.80
Europe	3.40	4.60	4.50	6.70	8.70	10.50	13.00	16.70
Other a/	1.40	2.30	2.80	3.00	5.70	5.70	6.00	6.00
TOTAL	23.00	26.60	29.15	33.90	42.60	46.90	54.00	59.90

Source: International Solar Intelligence Report and Photovoltaic Insiders Report, various issues.

a/ The largest producers in this category are: India, Brazil, Taiwan Province of China, Venezuela and Algeria.

3. Solar thermal energy conversion

19. Solar water-heating is one of the most mature and widespread of the solar energy technologies. Solar water-heating represents significant savings over conventional energy use in many countries, such as Greece, Cyprus and Israel (see A/AC.218/1992/9). The market for solar water-heaters is largely commercial in the developed countries and the same holds true for some developing countries. In the European Community there were 3 million square metres (m^2) of solar collector area installed in 1990, Greece accounting for the bulk of those with a 52.55 per cent share. Ironically, Spain, Portugal and Italy, which have a favourable climate for solar energy technology, account for only 2.42, 5.25 and 2.42 per cent respectively of the market. The success of Greece is attributed to incentives given by the Government as far back as 1976, backed up by awareness campaigns in the 1980s. 8/

20. The conversion of solar thermal energy to electricity, which had been enjoying a small upswing in interest, mainly on the part of utility companies in the United States of America, has in more recent times had a setback: a California company that owned a 354 MW pilot plant backed up by natural gas lost the confidence of its investors, primarily as a result of uncertain and erratic tax incentives, and is now defunct.

4. Wind energy

21. Wind energy can be used for electricity production, pumping and mechanical power. Large-scale electricity production from so-called wind farms has received much attention lately and has also achieved some notable successes. As shown in table 6, global wind-turbine capacity reached 2,556 MW in 1992 and is expected to reach 2,797 MW in 1993. More than half of that capacity is located in California, with most of the rest located in Northern Europe. Among developing countries, only China, Egypt and India have some capacity. 9/ More

immediately useful for developing countries are the half to three quarters of a million wind pumps that are currently installed world wide, serving mainly livestock and village water supply. 10/

22. New technologies in wind power appear promising. For example, a private company and the Electric Power Research Institute (EPRI), working together in the United States of America, have been developing a variable-speed wind turbine since 1988. Electricity from those turbines, at a cost of 5 cents per kilowatt-hour (cents/kWh), is on a par with newly built coal- and gas-fired power stations. It also costs 4 cents/kWh less than traditional non-variable-speed wind turbines. 11/

Table 6. Selected grid-connected wind-turbine capacity

(Megawatts)

Country	Wind-turbine capacity				Net installed electricity capacity
	1990	1991	1992	1993 a/	1990
United States of America	1 557	1 600	1 600	1 600	775 396
Denmark	412	418	470	520	9 133
Netherlands	45	83	116	120	17 441
Germany	47	90	170	220	123 160
United Kingdom of Great Britain and Northern Ireland	8.8	10	30	131	73 059
Spain	7.2	15	45	57	43 273
Belgium	4.2	6	6	6	14 140
Italy	1	5	10	20	56 548
Greece	-	5	26	26	8 508
Portugal	0.48	2	2	2	7 381
Egypt	2	..	..	..	11 738
Sweden	7.7	8	12	12	34 189
France	0.2	1	1	1	103 410
Ireland	0.12	..	7	[illegible]	3 807
India	6	37	41	54	75 995
Canada	5	20	20	20	104 140
China	19	..	..	..	98 600
TOTAL	2 122.7	2 300	2 556	2 797	1 559 918
Annual increase	-	177.3	256	241	-

Source: Wind-turbine capacity, 1990: World Energy Council; wind-turbine capacity, 1991, 1992 and 1993: E. Sesto, "Wind energy, present situation and future prospects", paper presented at the World Solar Summit, Paris, 5-9 July 1993; Net installed electricity capacity, 1990: Department for Economic and Social Information and Policy Analysis, United Nations Secretariat, 1990 Energy Statistics Yearbook (United Nations publication, Sales No. E/F.92.XVII.3).

a/ Projected.

5. Biomass, fuelwood and charcoal

23. By the end of the 1980s biomass constituted some 20 per cent of the energy consumed in developing countries. The lack of access to sustained supplies and inefficient use of fuelwood are still among the most urgent energy problems faced by the rural population in developing countries.

24. As indicated in table 7, 1.4 billion tons of wood was used in 1990, either as fuelwood or in other energy production, representing half of all wood consumption. Wood and wood residues used directly for energy production amounted to 0.57 billion toe in 1990, about 15 per cent of global oil consumption.

25. In developing countries, 80 per cent of annual wood production is used for fuel, of which 90 per cent is used directly as fuelwood and most of the rest is made into charcoal. 9/ Attempts to alleviate some of the problems associated with fuelwood use, such as the dissemination of efficient cooking stoves in several countries, have had varied results. The benefits of many of the stoves have in some cases not been apparent to their end-users. New approaches need to be developed for the process of distributing improved stoves to become more efficient and accepted. Biogas systems using other biomass feeds, such as dung, have been introduced in some countries on a massive and widespread scale but have had very mixed results due to complex sociocultural factors.

26. In developed countries, increased efficiency of mainly forest-product residues in industrial boilers and for power production has been successfully realized. For example, much of the 6,500 MW biomass-based power capacity of the United States of America is owned and operated by the forest-products industry to meet its own energy needs. Most of the industry's plants came on line during the 1980s with the help of a federal tax credit that has since been removed, resulting in a decrease in the rate of new plants coming on line. 12/ In the European Community, biomass contributes 21.68 terawatt hours (TWh) to annual electricity generation, about 1 per cent of the total. Forest residues, agricultural waste, industrial waste, municipal waste and landfill contribute 20.6 mtoe or about 3 per cent of total heat generation in the European Community. 8/

27. Biomass is also used to produce ethanol for transportation fuel. In Brazil, an extensive ethanol programme produced an amount that corresponds to 4.5 mtoe from sugar cane in 1992 at a cost of about US$ 40 per barrel of oil equivalent. 13/

28. Research and development activities, involving various aspects of biomass production, conversion and energy use, have increased over the past 10 years. Investigations of fast-growing species, harvesting techniques and equipment and conversion techniques (such as gasification, pyrolysis, liquefaction and carbonization) have taken place in several countries, including some developing countries. In general, large-scale generating plants will probably choose gas-turbine-based technologies in the near future. New developments in ethanol production include the use of genetically engineered bacteria to assimilate and ferment biomass. Agricultural, industrial and municipal waste can be used as feed. The processes involved can produce ethanol at less than half the cost of

the corn-based production method currently used in the United States of America. 14/

29. Biomass figures prominently in many scenarios that predict an optimistic future for renewable energy sources. The biomass would come from agricultural residues and livestock wastes; wood and municipal wastes; and agricultural products, such as sugar cane, that are specifically grown for the purpose of energy production. However, the use of biomass for liquid and gaseous fuels and for direct energy production might create enormous problems for competing uses, such as food production.

30. According to a survey of tropical forests in 76 countries by the Food and Agriculture Organization of the United Nations, the rate of deforestation rose to 0.9 per cent per year in the 1980s, as compared to 0.6 per cent during the period 1976-1980. Alarming trends can also be observed in West Africa where the rate of forest loss is 2.1 per cent per year, and in Central America and Mexico, where it has reached 1.8 per cent per year. 15/

Table 7. Wood and wood residue for energy use, 1990

Countries	Billion tons of wood	Billion tons of oil equivalent
Developing countries	1.1	0.4
Developed countries	0.3	0.17
Total	1.4	0.57

Source: World Energy Council, 1992 Survey of Energy Resources.

6. Hydropower

31. In terms of energy output, large-scale hydropower is second only to biomass among renewable sources of energy. However, although it is a renewable source of energy with enormous untapped potential, especially in developing countries, large-scale hydropower has met with significant opposition lately, mainly because of environmental concerns.

32. Smaller hydropower resources that do not require the same large infrastructure for exploitation also have a large potential but are little surveyed. Installed hydropower capacities are shown in table 8.

Table 8. Small and larger-scale hydropower capacity in operation in 1990

(Megawatts)

Region	Larger-scale a/	Small-scale b/	Total	Small as percentage of large
Africa	19 925	258	20 183	1.3
Latin America	93 804	409	94 213	0.4
North America	146 381	799	147 180	0.5
Asia	110 512	4 285	114 797	3.9
Central Europe and former USSR	82 974	2 152	85 126	2.6
Western Europe	129 422	3 484	132 906	2.7
Middle East	3 140	4	3 144	0.1
Oceania	11 903	82	11 985	0.7
WORLD TOTAL	598 061	11 473	609 534	1.9

Source: World Energy Council, 1992.

a/ Including plants with a capacity greater than 2 megawatts.

b/ Including plants with a capacity less than 2 megawatts.

7. Geothermal energy

33. High-temperature geothermal resources suitable for electricity generation probably exist in about 28 countries, while resources suitable for direct utilization of heat exist in about 30 countries. The total installed capacity of geothermal electricity production increased from 1,278 MW in 1975 to 5,876 MW in 1990, with some projections indicating an even faster increase to 15,000 MW by the year 2000. Among the developing countries 81 per cent of total capacity - 1,955 MW - is installed in only two countries, Mexico and the Philippines. About 70 per cent of the installed capacity in industrialized countries is in the United States of America. The installed capacity for geothermal energy for direct use was 11,500 megawatt-thermal (MWt) at the end of 1989 and was projected to reach 23,000 MWt by 2000.

8. Bitumen and tar sands

34. Significant development has taken place in the bitumen industry over the past few years. Venezuela has been marketing its Orinoco bitumen in the form of an emulsion called orimulsion to electrical power plants. The product is currently used successfully in Canada, Japan, the United States of America and the United Kingdom of Great Britain and Northern Ireland. In the United Kingdom, pollution control authorities recently approved regular use of orimulsion in two power stations. Four Japanese companies have recently placed commercial orders. China is also conducting feasibility studies and is considering participating in the construction of an orimulsion plant in Venezuela. In 1993 the Venezuelan Congress was asked to approve a joint venture between Maraven (a subsidiary of PDVSA, the national oil company of Venezuela) and Total (of France), and Itochu and Marubeni (of Japan); the venture would exploit and upgrade 114,000 barrels per day (b/d) of the bitumen in the Orinoco Tar Belt, generating some US$ 22 billion over 20 years. 16/

35. The province of Alberta in Canada holds one of the world's largest deposits of tar sands, some 1.7 trillion barrels of oil in place. The Athabasca sands, which are the home of two large recovery and processing plants operated by Syncrude Canada Ltd. and Suncor Inc., hold about 870 billion barrels in reserves and in 1992 produced 88 million barrels of synthetic light crude. In 1992, production from the two operations reached a cumulative total of 1 billion barrels and yearly production is increasing steadily even as conventional oil production is declining in Canada. Syncrude, which processes 325,000 tons of tar sands a day to produce 390,000 b/d of diluted bitumen, is the largest mining operation in the world in terms of ore processed. Because there are no finding costs involved for the Canadian tar sands, their reported operating cost of US$ 15/b is now close to the cost of finding and producing new oil in Canada.

B. Energy, including new and renewable sources of energy, and the United Nations Conference on Environment and Development

36. UNCED, which was held in Rio de Janeiro from 3 to 14 June 1992, adopted the Rio Declaration on Environment and Development, 17/ Agenda 21 18/ and the Non-legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests. 19/

37. Energy issues were extensively covered by UNCED, either by direct reference or by implication. For example, a number of the 27 Principles included in the Rio Declaration are relevant to energy, including new and renewable sources of energy, such as the sovereign right of States to exploit their own resources pursuant to their own environmental and developmental policies (Principle 2); the right to development (Principle 3); the essential task of eradicating poverty (Principle 5); the call for States to reduce and eliminate unsustainable patterns of production and consumption (Principle 8); and the call for States to enhance the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies (Principle 9).

38. Similarly, 17 of the 40 chapters of Agenda 21 are directly relevant to energy, especially chapter 4, "Changing consumption patterns"; chapter 7, "Promoting sustainable human settlement development"; chapter 9, "Protection of the atmosphere"; and chapter 14, "Promoting sustainable agriculture and rural development".

39. While the objective of the present report is not to provide a comprehensive analysis of energy and Agenda 21, it may be noted that the Agenda places emphasis on energy conservation and efficiency as well as new and renewable sources of energy. For example, in chapter 9, programme area B, subprogramme 1, entitled "Energy development, efficiency and consumption", Governments at the appropriate level, with the cooperation of the relevant United Nations bodies and, as appropriate, intergovernmental and non-governmental organizations, and the private sector, are urged to:

> "(a) Cooperate in identifying and developing economically viable, environmentally sound energy sources to promote the availability of increased energy supplies to support sustainable development efforts, in particular in developing countries;
>
> "(b) Promote the development at the national level of appropriate methodologies for making integrated energy, environment and economic policy decisions for sustainable development, inter alia, through environmental impact assessments;
>
> "(c) Promote the research, development, transfer and use of improved energy-efficient technologies and practices, including endogenous technologies in all relevant sectors, giving special attention to the rehabilitation and modernization of power systems, with particular attention to developing countries;
>
> "(d) Promote the research, development, transfer and use of technologies and practices for environmentally sound energy systems, including new and renewable energy systems, with particular attention to developing countries;
>
> "(e) Promote the development of institutional, scientific, planning and management capacities, particularly in developing countries, to develop, produce and use increasingly efficient and less polluting forms of energy;
>
> "(f) Review current energy supply mixes to determine how the contribution of environmentally sound energy systems as a whole, particularly new and renewable energy systems, could be increased in an economically efficient manner, taking into account respective countries' unique social, physical, economic and political characteristics, and examining and implementing, where appropriate, measures to overcome any barriers to their development and use;
>
> "(g) Coordinate energy plans regionally and subregionally, where applicable, and study the feasibility of efficient distribution of environmentally sound energy from new and renewable energy sources;

"(h) In accordance with national socio-economic development and environment priorities, evaluate and, as appropriate, promote cost-effective policies or programmes, including administrative, social and economic measures, in order to improve energy efficiency;

"(i) Build capacity for energy planning and programme management in energy efficiency, as well as for the development, introduction, and promotion of new and renewable sources of energy;

"(j) Promote appropriate energy efficiency and emission standards or recommendations at the national level, aimed at the development and use of technologies that minimize adverse impacts on the environment;

"(k) Encourage education and awareness-raising programmes at the local, national, subregional and regional levels concerning energy efficiency and environmentally sound energy systems;

"(l) Establish or enhance, as appropriate, in cooperation with the private sector, labelling programmes for products to provide decision makers and consumers with information on opportunities for energy efficiency." (para. 9.12)

40. Similarly, in chapter 14, programme area K, entitled "Rural energy transition to enhance productivity", Governments at the appropriate level, with the support of the relevant international and regional organizations, are urged to:

"(a) Promote pilot plans and projects consisting of electrical, mechanical and thermal power (gasifiers, biomass, solar driers, wind pumps and combustion systems) that are appropriate and likely to be adequately maintained;

"(b) Initiate and promote rural energy programmes supported by technical training, banking and related infrastructure;

"(c) Intensify research and the development, diversification and conservation of energy, taking into account the need for efficient use and environmentally sound technology." (para. 14.95)

C. New policies and plans for the development of new and renewable sources of energy

41. Since UNCED, worldwide interest in new and renewable sources of energy has been renewed, particularly with regard to new policies and plans at both national and multilateral levels. While no comprehensive survey of such new plans and policies is yet available, there are indications that both industrialized and developing countries are attempting to formulate new policies, plans and targets, in some cases involving increased renewable energy use.

42. In India, the Government has adopted a new strategy and action plan aimed at a significant increase in the contribution of non-conventional energy sources during the remaining years of the Eighth Plan (1992-1997), with a market-orientation strategy and active private-sector participation. 20/ With the help of private entrepreneurs, the Government hopes to install an additional 1,655 MW of renewable energy, in contrast to the 600 MW capacity envisaged in the original plan.

43. The plan includes increased application of solar PV technology in unelectrified or remote rural areas in order to provide: (a) lighting, mainly by distributing 100,000 solar lanterns as compared to the 10,000 originally planned, as well as 100 solar PV power packs; and (b) water pumping, by launching the installation of 50,000 deep-well, solar PV pumps, with the first 1,000 pumps to be installed in the first phase (1993-1994). The strategy also calls for wider application of solar thermal energy, with an initial focus on the use of industrial water-heating systems for industries that have continuous requirements; domestic heating systems; the installation of solar thermal systems in government buildings; a market campaign for the sale of solar cookers; and use of passive solar features in the design and construction of buildings, in collaboration with engineers and architects. A major thrust of the strategy will be the launching of a national programme for bio-energy utilization, with the participation of industry and municipal bodies, which will add generating capacity in the following fields: co-generation of power (150 MW); recycling of industrial waste (150 MW); utilization of urban and municipal wastes (100 MW); biomass gasification (50 MW); and biomass densification (briquetting) (50 MW). All potential beneficiaries and households in a universalized rural cooking energy programme of biomass and improved chulhas (cooking stoves) are to be covered in the foreseeable future, with about 20 to 23 per cent to be covered by the end of the Eighth Plan. Under the programme, non-functional biogas plants will also be taken up for repairs. The new strategy and action plan will also initiate new pilot projects to be set up in the new and emerging areas of renewable technologies, such as tidal power, ocean thermal energy conversion, alternate fuels for surface transportation, chemical sources of energy, hydrogen energy, geothermal energy and magneto-hydrodynamics.

44. India and China have successfully established, as a matter of policy, institutional infrastructures for assisting and promoting renewable energy use, such as very large national extension programmes that involve participation from the level of ministries through state and local organizations, down to the village level. There are also well-established manufacturing organizations, financing organizations, research and development facilities, training, and testing and standardization organizations.

45. Renewable energy use, in particular PV use, has also experienced growth and relative success in some other developing countries, such as the Dominican Republic, Sri Lanka and Kenya, assisted by concessional interest rates and the abolition of import tariffs on equipment.

46. Some developed market economies have also initiated plans. For example, Denmark's Energy 2000 includes targets for 800 to 1,350 MW of wind power by the year 2000, 1,500 MW by the year 2005 and biomass 1 million toe by the year 2005.

Spain has a target of 3,749 Mtoe contribution of renewables by the year 2000, of which biomass would contribute 74.9 per cent, municipal solid waste 10.3 per cent, small hydro 8 per cent, active solar 2.7 per cent, geothermal 0.3 per cent and PV 0.1 per cent. Germany's targets include 250 MW of wind and 2,250 PV units with a capacity of 1 to 5 kW each by 1995.

47. ALTENER, a programme proposed by the Commission of the European Communities, targets an increase in the contribution of renewables from the current 4 per cent to 8 per cent of total energy supply in the Community by the year 2005. Such an increase would involve tripling electricity production derived from renewables, not including large-scale hydropower, and would secure a 5 per cent share for biofuels in the motor-vehicle fuel market. The programme has been budgeted at 40 million European currency units (ECU) during 1993-1997 and will include the setting of quality and performance standards for small hydro, wind and solar thermal collector systems; mapping and data collection of small hydro and geothermal resources; reduction of tax on biofuels to a maximum of that on fossil fuels; guarantees for especially risky geothermal projects; pilot projects for biofuels, energy crops and biogas from livestock; aid to planning and feasibility studies; training for architects in passive solar designs; and provision of infrastructure, training and information exchange. 8/, 21/

48. Because of growing concerns with the effect of carbon dioxide (CO_2) emissions from fossil fuels on climate change, various schemes have been proposed with the aim of reducing their consumption through higher carbon and/or energy taxes. Proposals for energy taxes often exclude renewables sources as an incentive for their accelerated development.

49. Among the countries of Western Europe, Denmark, Finland, the Netherlands, Norway and Sweden have already introduced carbon taxes. The impact of the taxes varies, since major carbon emitters and energy-intensive industries are in some cases exempted. 22/ Under a proposal of the Commission of the European Communities, a carbon/energy tax would be introduced and raised progressively to US$ 10/barrel of oil equivalent by the year 2000. 8/

50. In the United States of America, a variety of measures adopted since the energy crises of the 1970s have favoured the development of new and renewable sources of energy. The Clean Air Act of 1990, which introduced tradeable permits for sulphur dioxide (SO_2), also made it possible for utilities that buy power generated by renewable energy to sell pollution allowances for use after 1995. The Energy Policy Act of 1992 provided for a tax credit of 1.5 cents/kWh for renewable energy. This has resulted in increased interest from utilities and the renewable energy industry is starting to develop standards for manufacture in anticipation of broader use. The federal research budget for renewables increased 46 per cent from 1990 to 1991. 23/

51. In February 1993, the Administration of the United States Government made a proposal to Congress for an energy tax of 59.9 cents per million British thermal units (Btu) for oil; 25.7 cents/million Btu tax for gas, nuclear and hydro; and no tax at all on solar and wind energy. It was estimated that the proposal would reduce oil imports by 350,000 b/d and raise government revenue by US$ 71.4 billion over a five-year period. The proposal was not approved by the

United States Congress. Instead, a tax of 4.3 cents/gallon on gasoline and diesel was enacted from 1 October 1993, which was estimated to provide government revenue of US$ 23 billion over the same period.

III. PROSPECTS FOR NEW AND RENEWABLE SOURCES OF ENERGY AND CONCLUSIONS

A. Future impact of new and renewable sources of energy on the global energy picture

52. Because of misconceptions about the energy resource base and prospective energy prices trends, the energy crises of the 1970s led for a while to heightened concerns about the adequacy of energy resources in meeting increases in energy demand. Forecasts of prices rising as high as US$ 100/barrel of oil were not uncommon and a pessimistic outlook prevailed that underestimated both the available reserves of natural resources and the potential for technological progress. Consequently, both Governments and business embarked on very substantial research and development programmes in the areas of new and renewable sources of energy and energy conservation and efficiency.

53. However, since that time, changing global energy trends have resulted in lower energy prices, more plentiful energy supplies, surplus energy production capacities and increasing energy reserves. As a result, although energy conservation and efficiency efforts and the application of rapidly developing technologies in the exploration and development of conventional energy resources have made a significant impact on the current energy situation, and although traditional sources of energy continue to be important in many developing countries, especially the least developed countries, the global contribution of new and renewable sources of energy has remained very small.

54. Government and business efforts have extended to the construction and operation of experimental and commercial projects, such as in the areas of oil shale in the United States of America and sugar-cane alcohol in Brazil. However, despite engineering estimates of US$ 8/barrel of oil from shales, costs reached more than US$ 45/barrel in a subsidized plant which has since been shut down. Costs of sugar-cane alcohol plants are estimated at more than US$ 40/barrel of oil equivalent, although they continue to supply most of the gasoline market in Brazil.

55. In sum, the change in the global energy situation noted above, together with the lack of technological breakthroughs in new and renewable sources of energy and the generally high costs of commercial and experimental plants, has led to severe cutbacks and abandonment of efforts in the field, including drastic reductions in research and development expenditures.

56. In more recent years, the rationale of energy conservation has shifted from apprehensions about the adequacy of reserves to concern about environmental degradation, which is partly caused by the increasing consumption of fossil fuels; the fear of climate change is especially prevalent. At the same time, as described above, some successes have been registered in new solar, wind, heavy-oil and tar-sands technologies, among others.

57. Unfortunately, cost comparisons between fossil fuels and new and renewable sources of energy are difficult to make. Estimates of environmental costs and their internalization into other costs for each energy source are still only theoretical and cannot be tested in the market-place. Consequently, available future energy scenarios and projections on new and renewable sources of energy are often based on untested assumptions and optimistic technological forecasts that foresee a rapid reduction in costs, which may or may not happen. Moreover, either explicit or implicit assumptions of governmental subsidies and/or massive government-supported research and development programmes are incorporated into such scenarios at a time when worldwide trends are moving towards free-market economies and less government involvement in business efforts.

58. The United Nations Solar Energy Group on Environment and Development (UNSEGED), in its report to the sixth session of the Committee on the Development and Utilization of New and Renewable Sources of Energy (A/AC.218/1992/5/Rev.1, annex), concluded that in the short term hydro and biomass would continue to be the main contributors to new and renewable sources of energy. New biomass and photovoltaic technologies would become important in the early years of the next century. By the year 2020, new and renewable sources of energy would supply about one third of world energy consumption. Under a more optimistic scenario of improved energy efficiency, their contribution could be as high as one half. However, such a rapid development would require an array of policy changes and practices by Governments and business, including full environmental costing of all energy sources.

59. The World Energy Council (see table 9) projects a gradual increase in the contribution of new and renewable sources of energy during the next three decades, on the assumption that current policies will continue and that the pace of its ecologically driven scenario will accelerate.

Table 9. World Energy Council projections for renewable energy contribution in 1990, 2000, 2010 and 2020

(Million tons of oil equivalent)

	Current policies scenario		Ecologically driven scenario	
Year	New renewables a/ as percentage of global energy	Total renewables b/ as percentage of global energy	New renewables a/ as percentage of global energy	Total renewables b/ as percentage of global energy
1990	1.9	17.7	1.9	17.7
2000	2.2	18.7	3.1	19.9
2010	2.8	19.5	5.9	22.7
2020	4.0	21.3	12.1	29.6

Source: World Energy Council.

a/ Including solar, wind, geothermal, ocean/tidal, mini-hydro and modern biomass.

b/ Including large-scale hydro and traditional biomass.

B. Conclusions

60. Various technologies in the field of new and renewable sources of energy have reached maturity and others promise to do so in the medium term. Despite their apparent technical and economic feasibility, such technologies have not yet found widespread use in either developed or developing countries. In some cases, electricity utilities in developed and developing countries have been persuaded or obliged through regulations to incorporate into their systems independently generated electricity. In other cases, private-sector initiatives have been quite successful without government intervention.

61. New institutional developments connected with the deregulation and privatization of energy utilities may provide opportunities for expanded investments of private capital by indigenous entrepreneurs and/or arrangements similar to the so-called build-operate-transfer schemes involving foreign direct investment.

62. Governments could play a useful role in promoting new and renewable sources of energy by initiating surveys to establish their potential in both urban and rural areas; market surveys to gather comprehensive information on their costs and benefits, including environmental effects; and, where appropriate, differentiated corporate taxation that would reward ecological responsibility while establishing a level playing field for all energy sources.

63. The Committee may wish to consider ways and means of facilitating the exchange of information and country experiences in such activities and projects in its future work programme.

Notes

1/ Report of the United Nations Conference on New and Renewable Sources of Energy, Nairobi, 10-21 August 1981 (United Nations publication, Sales No. E.81.I.24), chap. I, sect. A.

2/ See "Thin-film material share of PV market shrinks as module prices rise", Photovoltaic Insider's Report, vol. XII, No. 5 (May 1993).

3/ See "Report from Indonesia: 12,000 systems totalling 700 kW installed", Photovoltaic Insider's Report, vol. XII, No. 3 (March 1993).

4/ See "Alternative energy systems, with emphasis on rural areas in South Asia", UNDP TSS 1 study prepared by the Department of Economic and Social Development, United Nations Secretariat (April 1993).

5/ See Mark Hankins, Solar Rural Electrification in the Developing World (Washington, D.C., Solar Electric Fund, 1993).

6/ See "Report from Europe: ENEL building 3.3 MW grid-connected PV power in Italy", Photovoltaic Insider's Report, vol. XI, No. 1 (January 1992).

7/ See H. M. Kuhne and H. Aulich, "Solar energy systems: assessment of present and future potential", Energy Policy, vol. 20, No. 9 (September 1992).

8/ See L. F. Jesh, "Evolution and perspectives of the solar market: commercialization and dissemination in the European Community", paper presented at the World Solar Summit, Paris, 5-9 July 1993.

9/ See World Energy Council, 1992 Survey of Energy Resources (1992).

10/ See "Special issue on wind pumps", Renewable Energy for Development: A Stockholm Environment Institute Newsletter, vol. 6, No. 1 (June 1993).

11/ See "The Fourth Annual Discover Awards for Technological Innovation. Environment: reaping the wild wind", Discover, vol. 14, No. 10 (October 1993).

12/ See J. Tapper and R. San Martin, "Solar energy in North America", paper presented at the World Solar Summit, Paris, 5-9 July 1993.

13/ See C. Torra and M. Labrousse, "Energie solaire dans le monde iberoamericain", paper presented at the World Solar Summit, Paris, 5-9 July 1993.

14/ See "Alcohol-from-waste process wins honor of 5,000,000th patent", International Solar Energy Intelligence Report, vol. 17, No. 6 (22 March 1991).

15/ See H. Khatib, "Solar energy in developing countries", paper presented at the World Solar Summit, Paris, 5-9 July 1993.

16/ See "Approval sought for joint venture to exploit Orinoco oil", OPEC Bulletin (July/August 1993).

17/ United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992, vol. I, Resolutions Adopted by the Conference (United Nations publication, Sales No. E.93.I.8 and corrigendum), resolution 1, annex I.

18/ Ibid., annex II.

19/ Ibid., annex III.

20/ Government of India, Ministry of Non-Conventional Energy Sources, Strategy and Action Plan (May 1993).

21/ See M. Ward, "UK helps utilities move toward 2000 goal for renewables", International Solar Energy Intelligence Report, vol. 19, No. 15 (26 July 1993).

22/ Department for Economic and Social Information and Policy Analysis, United Nations Secretariat, World Economic Survey 1993 (United Nations publication, Sales No. E.93.II.C.1), chap. V.

23/ See "Renewable energy: clean profits", The Economist, vol. 328, No. 7830 (25 September 1993).